A STUDY ON THE RELATIONSHIP BETWEEN APPLIED TORQUE AND RESULTANT TENSION IN BOLT AND NUT ASSEMBLY

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BORANG PENYERAHAN LAPORAN PROJEK

Judul : **A STUDY ON THE RELATIONSHIP BETWEEN APPLIED TORQUE AND RESULTANT TENSION IN BOLT AND NUT ASSEMBLY**

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The project attached here, entitled **"A STUDY ON THE RELATIONSHIP BETWEEN APPLIED TORQUE AND RESULTANT TENSION IN BOLT AND NUT ASSEMBLY "** was prepared and submitted by **Colin Wong** as a partial fulfillment of the requirement for degree of Bachelor of Engineering with Honours (Mechanical Engineering and Manufacturing System) is hereby read and approved by:

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By

Colin Wong Tiing Ping

This project is submitted in partial fulfillment of
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Faculty of Engineering
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2004

Dedicated to my beloved family and friends those always support me.

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ABSTRACT

The tightening of the mechanically fastened joint such as a bolt and the nut assembly is a necessary and common operation in most machinery and mechanical system. The application of a torque to a nut, result in a clamping force in the bolt and nut fastener is a common engineering application. The main aim of this project is to investigate the effect of the thread condition on the resultant tension in the bolt. Beside that, is also investigating the effects of dissimilar bolt and material on the tightening process. The ER 420 Testing Hyperstatic Mechanical System is used to done the series o the experiment. The experiment is done on two different conditions of the bolt thread which is lubricant and without lubricant. Beside that, there are 3 different types of the material is chosen which is high tensile steel, galvanized zinc steel and stainless steel undergo the series of the experiment. The experiment resulted in a set of graph that clearly shown the relationship between the torque and stress created in bolt. Those result can be used as a reference guide for monitoring the performance of the bolts as this has been widely overlook in industry.

ABSTRAK

Pengetatkan skru dalam bidang kejuruteran mecahanical adalah sesuatu yang tugasan yang biasa tetapi selalunya kita telah mengabaikan kepentingannya. Tujuan utama bagi projek adalah mengaji hubungan di antara tork dengan beban yang dikenakan dalam sebuah skru dan bagaimana perbezaan dalam pekali geseran dalam skru boleh menpengaruhinya. Selain itu, projeck ini juga bertujuan mengaji bagaimana bahan yang berlainan dapat menpengaruhi bebean dalam skru. Peralatan ER 420 Testing Hyperstatic Mechanical System telah digunakan untuk menjalankan satu siri eskperimen sama ada dengan keadan berpelincir atau tidak berpelincir. Selain itu, bahan yang berlainan juga digunakan dalam eksperimen untuk mengaji keasnnya ke atas skru. Keputusan eksiperimen dipamerkan dalam bentuk graf untuk memudahkan bandingan dibuat. Keputusan yang diperolehi boleh digunakan oleh jurutera sebagai rujukn untuk memerhatikan keboleharaapn skru

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CHAPTER 1

INTRODUCTION

1.1 Background

Bolt and nut is invented in the middle of 1400's. In 1801, Henry Maudsely (English inventor) had built up the lathe that could cut the bolt of any diameter and pitch. There is no a uniform standard for the shape of the thread until 1841 when Joseph Whitworth proposed his paper about "A Uniform System of the Screw-thread" to Institution of Civil Engineers. He defined specifications for the pitch, depth and shape of the thread, and he specified that the angle between the threads should be 55°. The thread systems which we use today (ISO Inch Screw thread System and ISO Metric Screw Thread System) were introduced by International Organisation for Standardisation in 1964.

The usages of bolt and nut are very wide. It is used to clamp the parts together to seal the pressure within vessel or to prevent the motion between parts. It is also used to transmit the force from one part to another part. However, most of the times we have ignored how complex is the bolt and nut; we regard them as a simple object.

The clamp force generated by a bolt can be controlled indirectly by regulating the applied torque. The method, known as Torque Control, is by far the most popular method of controlling a bolt's clamp force. The initial clamp force generated by the bolt is frequently known as Preload.

There is a link between the torque applied to a bolt and the resulting preload. A problem would exist due to the friction that has a large influence on how much torque is converted into preload. Besides the torque is required to stretch the bolt (creating the tension in the bolt), torque is also required to overcome friction in the threads and under the nut face. Typically, only 10% to 15% of the torque is used to stretch the bolt, whereas of the remaining torque, 30% is dissipated in the threads typically and 50% to 55% is under the nut face. On account of the friction, it is such an important factor in the relationship between torque and preload, variations in friction has a significant influence on the bolt's preload.

Different bolt surface finishes have different friction values. The torque required for a socket headed screw will not be the same as that required for the same size as a hexagon bolt. The larger the bearing face of the standard bolt will result in increased torque being required as compared to a socket headed screw. This is because more torque is being dissipated between the nut face and the joint surface.

1.2 Project Objective

1.2.1 General

Most of the time, we just determined the amount of torque required to tight a bolt and ignored the tension of the bolt. Actually, what we really need is to know the amount of tension to tighten the nut into the bolt, not just a known amount of torque because the tension in the bolt would clamps the mating parts together.

This project is trying to find out the relationship between applied torque and the resultant tension in bolt and nut assembly. Beside that, this project is also trying to look at how the other factor will affect the resultant tension.

1.2.2 Specific

For this project, ER 420 Pre-Tensioned Bolt will be used in investigation of the behaviour of the bolted assembly. This equipment will analyse the stress and strain produced in the bolt of different tightening torque.

The main objectives of this project are to investigate:

- Effect of thread condition (coefficient friction) on the resultant tension in bolt or stud.
- Effect of dissimilar material of nut on the tightening process.

1.3 Definition of Terms

Bolt

Bolt is defined as a headed fasteners which has external thread that meet an exact, uniform bolt thread specification (such as M, MJ, UN, UNR, and UNJ) such that it can accept a nontapered nut. (http://euler9.tripod.com/bolt-database/boltdef.html)

Nut

Nut is a piece of metal with a thread hole in the centre, used for screwing onto a bolt to secure. (Oxford Advanced Learner's English dictionary 4th edition)

Torque

Torque is a measure of force- that tends to produce rotation. Hence, torque is also known as turning or twisting force. The torque will create tension. When the bolt and nut are tightened, the threaded angle in the bolt converted the applied turning force (torque) into tension in a bolt shank.

Torque is the result of multiplying the value of the force applied by the distance from the point of application.

Torque= Distance x Force applied

The formula had clearly shown that if the distance is different the same amount of the force applied will create different torque

Tension

Tension is the term used to indicate the amount of stress to place on a bolt or a fastener so that it remains within its elastic limit (threads in metal bolts and nuts have minute, unobservable elastic qualities).

CHAPTER 2

LITERATURE REVIEW

2.1 Classified threaded bolt.

Threaded fasteners are classified by shape, material and finish, which are specified by industry standards. According to John J. Viegas in his article 'Standards for Mechanical elements' most of the threads used today are base on the following thread standards:

a) United State thread

b) N thread

c) American national screw-thread system (develop in 1933)

d) Unified system (also known as Unified and American standard)

e) British Standard Whitworth (B.S.W)

f) British Standard Fine (B.S.F)

g) Whitworth truncated or American Truncated

h) Whitworth (developed as war standard 1994)

i) British Association Standard (B.A)

j) International Metric Standard

k) Unified miniature screw thread

i) Microscopic-objective screw thread

There are two distinct usages for screw threads and they usually demand different behaviour from the threads:

- A power screw such as a lathe lead screw or the screw in a car lifting jack which transforms rotary motion into substantial linear motion (or vice versa in certain applications)

- A threaded fastener similar to a nut and bolt which joins a number of components together by transforming rotary motion into linear motion, though in this case the translation is small.

Hexagon headed bolt

A typical hexagon headed bolt and nut are shownn in figure 2.1. Bolt shank is usually the same as the outside diameter - the major diameter of briefly size of the thread. The radiused fillet at the junction of shank and head reduces stress concentration.

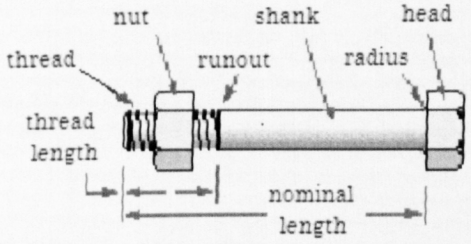

Figure 2.1 Hexagon Headed Bolt
(Source : http://www.mech.uwa.edu.au/DANotes/threads/intro/intro.html)

'Waisted' bolt

The shank diameter of a 'waisted' bolt is less than the thread diameter thus allowing a radiused thread run out that reduces stress concentration – beneficial for fatigue applications. The assembly illustrated incorporates a washer under the nut which promotes uniformity of contact - minimising damage to the underlying parts and again lessening stress concentration. The bolt head may be equipped with an optional washer face. A bolt's 'grip' is the combined thickness of the fastened parts.

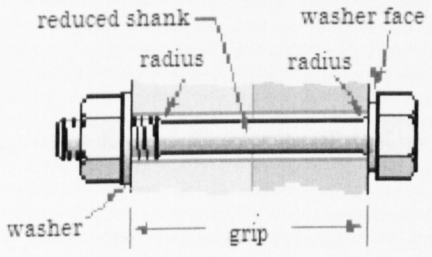

Figure 2.2 'Waisted' Bolt
(Source : http://www.mech.uwa.edu.au/DANotes/threads/intro/intro.html)

2.1.1 Thread-Form Terminology

Salient geometric features of the thread are illustrated in the figure below.

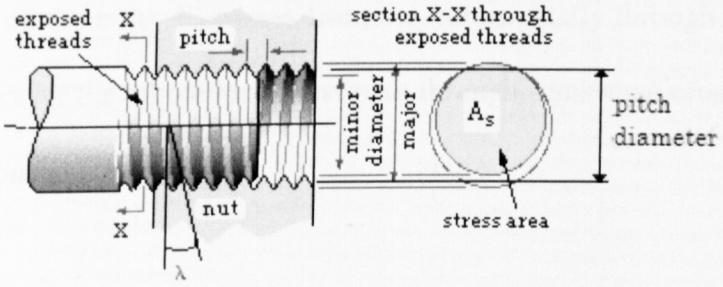

Figure 2.3 Geometric Feature of Thread
(Source: http://www.mech.uwa.edu.au/DANotes/threads/intro/intro.html)

Major diameter D_m, of a threaded screw or nut is the largest diameter of the screw thread.

Minor diameter D_r, is the smallest diameter of the screw thread.

Pitch diameter E, which is also called "effective diameter,"; is the diameter of an imaginary cylinder which surface would pass through the thread profiles at such point that is make the width of the groove equal to one-half the basic pitch. For a perfect thread, this occurs at the point where the widths of thread and groove are equal.

Pitch p, is the distance from a point on a screw thread to a corresponding point on the next thread measured parallel to axis.